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WINTER STORAGE AND PACKAGING EFFECTS ON LUCKY PEAK SEEDLINGS

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ABSTRACT

Six species of seedlings from nine different Lucky Peak Nursery seed lots were lifted in November and stored for the winter at both 28° and 33° F in both bag and crate packages. Initial survival and growth of study seedlings planted in the Boise, Payette, Sitgreaves, and Lincoln National Forests were compared with rates for seedlings from the same lots planted after conventional spring lifting. Results indicate that winter storage is generally feasible, but the best packaging method and lifting season differ with species. No advantage was gained by storing seedlings at the subfreezing 28° F temperature.

Several considerations make the feasibility of fall seedling lifting and winter storage important in the area served by Lucky Peak Nursery, Boise, Idaho.

National Forests in Arizona, New Mexico, and southern Utah experience optimal planting conditions in February or early March. Soils then dry rapidly, and prospects for seedling survival quickly decline. Weather and soil conditions at Lucky Peak Nursery seldom permit seedling lifting and delivery before mid-March.

The Boise and Payette National Forests in Idaho are evaluating fall lifting and planting of nursery stock as a means of increasing the efficiency of reforestation programs. Lucky Peak Nursery can regulate soil moisture to provide excellent lifting conditions in the fall, resulting in less seedling root damage than occurs with spring lifting. However, early storms at times prevent the completion of fall planting and some stock must be destroyed.

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If seedlings could be lifted in the fall and successfully stored during winter, some forests could hold unused fall planting stock for spring, other forests could receive trees for planting at the optimal time, and the nursery would have greater flexibility in scheduling lifting operations.

Stock lifted in the spring at Lucky Peak Nursery normally is stored at 33° F. To minimize molding and metabolic activity, others (Hocking and Nyland 1971; Hocking and Ward 1972) have stored trees at subfreezing temperatures. The results indicated that the lower temperature may be better for a long winter storage period, providing the below-freezing conditions do not damage the trees.

Both bags and crates have been used successfully to package spring-lifted stock. We were interested in comparing bag and crate storage to determine if desiccation occurs in crated seedlings at subfreezing temperatures.

The primary objective of this study was to determine if fall-lifted seedlings stored at 28° or 33° F will survive and grow as well as spring-lifted seedlings handled by standard procedures. A secondary objective was to determine if packaging methods (bags, crates) influence the survival and growth of seedlings subjected to the different lifting schedules and storage regimes.

METHODS

In November, 1972, after an oscilloscope trace indicated dormancy, we lifted (fig. 1) 1-0 ponderosa pine (*Pinus ponderosa* Laws.), 2-0 lodgepole pine (*Pinus contorta* Dougl.), 2-0 Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), and 3-0 Engelmann spruce (*Picea engelmannii* Parry) from stock scheduled for planting on the Boise National Forest; 2-0 ponderosa and 1-0 western larch (*Larix occidentalis* Nutt.)

Figure 1.—Study seedlings were lifted in November at Lucky Peak Nursery.

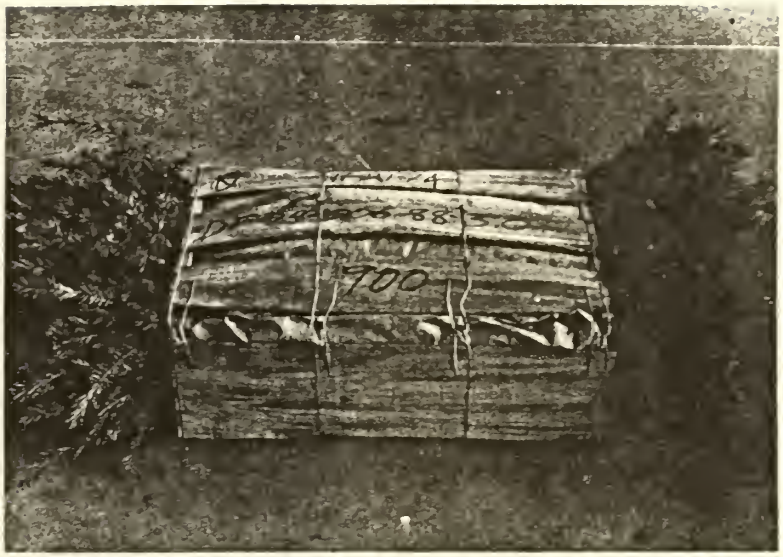

Figure 2.--Seedlings were packaged root-to-root in crates.

from stock scheduled for the Payette National Forest; 2-0 ponderosa pine from stock scheduled for the Sitgreaves National Forest, Arizona; 2-0 ponderosa pine from stock scheduled for the Lincoln National Forest, New Mexico; and 1-0 bitterbrush (*Purshia tridentata* (Pursh) DC.) from stock scheduled for the Idaho Fish and Game Department to be planted within Boise National Forest boundaries.

The use of an oscilloscope to determine seedling dormancy is a recent research development. Manuscripts are being prepared describing the technique, which has proven successful in numerous field tests.

Half of each lot of trees and shrubs was packaged in bags and half in crates on the day the seedlings were lifted. Crates were 22-1/2 inches long, 16 inches wide, and 7-1/2 inches deep. A 24-inch strip of Fibreen 200,[2] a waterproofed and fiber-reinforced kraft paper, was used to line the crates. A 1-1/2- to 2-inch layer of clean, well-moistened sphagnum moss covered the paper and alternate layers of moss and seedlings were placed into crates. The seedlings were placed root to root (fig. 2) in the approximate center of the crate. A final 1-1/2- to 2-inch layer of moist sphagnum was placed over the roots of the top layer of seedlings and the waterproof paper was gathered at the ends and rolled tightly. The crates were closed with four wire catches.

The seedling bags were 24- by 11- by 35-inch three-ply kraft paper with an inner layer of polyethylene that forms a moisture barrier. Two large handfuls of well-moistened sphagnum moss were placed in the center of the bottom of the seedling bag. Seedlings were placed in layers with roots over the moss. Two large handfuls of moss were used to cover the roots of the top layer of seedlings. The bag (fig. 3) was closed and rolled tightly to expel the air. The rolled seal was then taped with four strips of 1-inch nylon reinforced tape.

Considerably more sphagnum was used in crate packaging. One thousand seedlings packed in crates weigh 20 to 25 pounds more than equivalent seedlings packaged in bags.

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[2] The use of trade names in this publication is solely for the convenience of the reader. Such use does not constitute an official endorsement by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Figure 3.--Bags were tightly rolled to expel air.

Half of each lot of packages was placed in refrigerated storage maintained at 28° F. The other half was placed in storage maintained at 33° F. Relative humidity varied between 52 and 69 percent in 28° F storage and between 85 and 92 percent in 33° F storage (fig. 4).

All spring-lifted stock was lifted during the period February 16 to March 28, 1973 (table 1). The lifting was done routinely except that seedlings for the study were taken from seedbed areas immediately adjacent to the fall 1972 study seedling lift areas. Thus, essentially the same soil and site characteristics prevailed for both fall- and spring-lifted seedlings of each stock.

The storage period at the nursery was not the same for all stock. Table 1 indicates both nursery and field storage periods. Because all seedlings for the Boise and Payette National Forests and the Idaho Fish and Game Department were held at the nursery until planting time, the seedlings stored at 28° F were placed in 33° F storage on April 2, and held at that temperature until shipped.

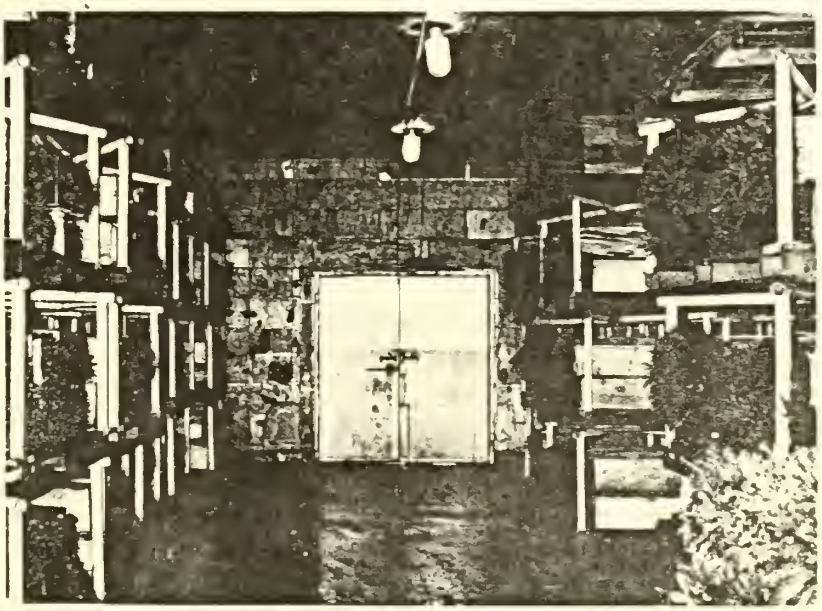

Figure 4.--Packaged seedlings were placed in refrigerated storage at 28° and 33° F.

Table 1.--*Lifting, storage, and planting schedules for seedling lots used in the study*

Cooperator	Species	Age class	Date planted 1973	Fall-lifted: Date lifted 1972	Fall-lifted: Days in nursery storage	Fall-lifted: Days from shipment until planting	Spring-lifted: Date lifted 1973	Spring-lifted: Days in nursery storage	Spring-lifted: Days from shipment until planting
Boise N.F.	Ponderosa pine	1-0	5/8	11/13	171	5	3/28	36	5
Boise N.F.	Lodgepole pine	2-0	5/8	11/13	171	5	3/6	58	5
Boise N.F.	Douglas-fir	2-0	5/8	11/13	171	5	3/7	57	5
Boise N.F.	Engelmann spruce	3-0	5/8	11/13	171	5	3/6	58	5
Payette N.F.	Ponderosa pine	2-0	5/17	11/13	185	0	3/19	59	0
Payette N.F.	Western larch	1-0	5/18	11/13	185	1	2/16	90	1
Sitgreaves N.F.	Ponderosa pine	2-0	5/22	11/6	133	64	3/12	7	64
Lincoln N.F.	Ponderosa pine	2-0	4/4	11/8	100	47	3/13	0	21
Idaho Fish & Game	Bitterbrush	1-0	4/25	11/13	163	0	2/16	68	0

After the seedlings left the nursery, the stock handling, site preparation, and planting procedures and site conditions varied among cooperators. Therefore, the field plantings should be considered as separate experiments for each stock. The experimental design for all was randomized block with three replications. Each plot contained 50 planted seedlings. Selected comparisons among treatment means were made using a sequential method (Snedecor 1956, p. 253).

BOISE STOCK

From May 4 to May 8, 1973, plots for each species shipped to the Boise National Forest were completely cleared to mineral soil using handtools. All stock was removed from the nursery 33° F storage on May 3, 1973, and transported to the planting site. Temperatures within the root zone of the seedlings in the crates held at 36° F during transporting. At the planting site the stock was placed in cool shade, covered with a light colored tarp, and permitted to reach ambient air temperature before auger planting on May 7 and 8, 1973. The planting was done by a team of two augermen and six planters. Fifty 4- by 14-inch holes were bored in each plot ahead of the planters.

The planting site was on granitic soil at an elevation of about 5,000 feet. The ponderosa pine and Douglas-fir were planted on a south aspect, the lodgepole pine on an east aspect, and the Engelmann spruce in a cove.

Approximately three-fourths inch of rainfall was received during and just after planting. The growing season was normal, with little precipitation during July and August. There were no extended periods of hot weather.

First-year survival and growth measurements (table 2) were taken September 11.

Table 2.--*Mean survival and height growth, and statistical significance[1] for the four seedling lots planted on the Boise National Forest*

Time of Lifting	Storage temperature	Package	Ponderosa pine: Survival	Ponderosa pine: Height growth	Lodgepole pine: Survival	Lodgepole pine: Height growth	Douglas-fir: Survival	Douglas-fir: Height growth	Engelmann spruce: Survival[2]	Engelmann spruce: Height growth
	°F		*Percent*	*Cm*	*Percent*	*Cm*	*Percent*	*Cm*	*Percent*	*Cm*
Fall	28	Bag	98 a	7.3 a	100 a	9.8 a	75 a	6.3 a	95	4.6 ab
Fall	28	Crate	90 b	5.9 b	88 b	4.0 b	57 b	4.3 b	83	3.4 c
Fall	33	Bag	100 a	7.1 a	100 a	9.6 a	90 a	7.5 a	93	4.7 a
Fall	33	Crate	98 a	6.5 ab	98 a	11.2 a	76 a	7.4 a	99	4.9 a
Spring	33	Bag	98 a	5.3 c	96 a	10.2 a	96 a	3.7 b	97	3.9 bc
Spring	33	Crate	98 a	5.6 bc	100 a	9.4 a	93 a	3.2 b	97	4.4 ab

[1] In each column of the table, all means followed by the same letter do not differ significantly at the 95 percent confidence level.

[2] Analysis of variance revealed no significant differences between treatments for survival, at the 95 percent level, so we chose not to make a comparison between means.

PAYETTE STOCK

During late summer and fall of 1972 the Payette National Forest planting sites were prepared using a medium-size bulldozer with a brush-piling or land-clearing blade. The majority of the site was completely cleared to mineral soil.

All stock was removed from the nursery 33° F storage on May 17, 1973, and transported during the early morning hours in an insulated container. The 2-0 ponderosa pine was removed from the transporting container and placed in cool shade. Trees were auger-planted by a team of one augerman and three planters, alternately planting behind the auger. The auger holes were approximately 4 by 14 inches. The planting site is an east-facing slope with basaltic soils that are 15 to 30 inches deep with some broken rock. The elevation is 5,500 feet. Precipitation during the growing season was below normal and mean maximum temperatures for May, June, July, and August were slightly above normal.

The 1-0 western larch was removed from nursery storage on May 17, 1973, transported to the planting site, and held overnight at approximately 40° F. Trees were auger-planted on May 18. There were six planters in the planting crew. The planting site was on an east-facing, 2-percent slope with granitic soil 18 inches deep. The weather during the growing season was warmer than normal, with less rainfall.

First-year survival and growth measurements (table 3) were taken for the pine on September 6, and for the larch on October 2.

Table 3.--*Mean survival and height growth, and statistical significance*[1] *for the two seedling lots planted on the Payette National Forest*

Time of lifting	Storage temperature	Package	Ponderosa pine		Western larch	
			Survival	Height growth[2]	Survival[2]	Height growth[2]
	°F		*Percent*	*Cm*	*Percent*	*Cm*
Fall	28	Bag	100 a	5.8	95	19.5
Fall	28	Crate	64 b	3.4	99	15.0
Fall	33	Bag	100 a	6.3	93	17.9
Fall	33	Crate	88 a	5.0	98	17.9
Spring	33	Bag	100 a	6.0	97	17.6
Spring	33	Crate	98 a	5.8	96	17.7

[1] In each column of the table, all means followed by the same letter do not differ significantly at the 95 percent confidence level.

[2] Analysis of variance revealed no significant differences at the 95 percent level, so we chose not to make a comparison between means.

SITGREAVES STOCK

The fall-lifted stock for the Sitgreaves National Forest was held in nursery storage at the assigned temperatures until March 19, 1973, when it was removed and shipped in a refrigerated van (33° to 34° F) to the planting site. The spring portion of the stock was lifted on March 12, 1973, and stored at 33° F until it was shipped with the fall stock.

The stock was received at the planting site on March 21, 1973. Trees were stored in a snow cache. No temperature or humidity readings were taken. The planting site was a flat ridgetop with cobbly loam soils. Because of an unusually wet year, planting was delayed until May 21 and 22, 1973. Trees were planted by a crew of three using planting bars. Each crew member planted one block. There was a late, wet spring, summer rains were below normal, and the fall months were dry.

First-year survival and height growth (table 4) were measured September 18.

Table 4.--*Mean survival and height growth for ponderosa pine planted on the Sitgreaves National Forest*[1]

Time of lifting	Storage temperature	Package	Survival	Height growth
	°F		*Percent*	*Cm*
Fall	28	Bag	58	5.2
Fall	28	Crate	70	4.4
Fall	33	Bag	52	3.9
Fall	33	Crate	76	4.0
Spring	33	Bag	62	4.0
Spring	33	Crate	50	3.3

[1] Analysis of variance revealed no significant differences at the 95 percent level.

LINCOLN STOCK

The fall-lifted stock for the Lincoln National Forest was held in nursery storage at the designated storage temperatures until February 16, 1973, when it was removed and shipped on a refrigerated van (33° to 34° F) to the planting site. The stock was received on February 18, and stored in a refrigerated van at 33° to 40° F and 90 percent humidity until planted.

On March 13, 1973, the spring portion of the study stock was lifted, packaged, and shipped via airfreight the same day.

The planting site is on a ridgetop with a slight northeast aspect. Soils are generally dry loam with varying amounts of limestone rock. The elevation is 7,050 feet. The planting blocks were completely scalped of all vegetation before planting. As on the Sitgreaves Forest, planting was delayed until March 30 and April 4, 1973, by wet weather. The planting was done by a six-man crew. A 4-inch auger was used to bore planting holes approximately 4 by 14 inches. During planting there were cold temperatures with high humidities. Moisture received during the growing season was normal for April and May, but less than normal for the balance of the season. Temperature and humidity were normal for the growing season.

First-year survival and height growth (table 5) were measured September 17, 1973.

Table 5.--*Mean survival and height growth, and statistical significance*[1] *for ponderosa pine seedlings planted on the Lincoln National Forest*

Time of lifting	Storage temperature	Package	Survival	Height growth[2]
	°F		*Percent*	*Cm*
Fall	28	Bag	10 c	5.0
Fall	28	Crate	([3])	([3])
Fall	33	Bag	48 b	5.1
Fall	33	Crate	70 ab	5.6
Spring	33	Bag	88 a	5.5
Spring	33	Crate	90 a	5.8

[1] In each column, all means followed by the same letter do not differ significantly at the 95 percent confidence level.

[2] Analysis of variance revealed no significant differences at the 95 percent level, so we chose not to make comparisons between means for height growth.

[3] These seedlings were inadvertently removed from storage and mixed with nonstudy stock.

BITTERBRUSH STOCK

The bitterbrush stock provided for the Idaho Fish and Game Department was planted and measurements were made by Robert B. Ferguson, Wildlife Biologist, Intermountain Forest and Range Experiment Station. It was stored in the same manner as the Boise and Payette National Forest tree seedling stock. The spring stock was lifted and stored on February 16, 1973. All of the seedlings were removed from storage and planted on April 25, 1973. Individual 2- by 3-foot planting plots were scalped using a wheel tractor with terracing blade on a 3-point hitch. Planting was done by four planters using planting spades. The sites were south-facing slopes with granitic soil at an elevation of about 3,200 feet. The growing season was dryer and warmer than normal.

First-year survival was measured September 10, 1973 (table 6). Because of the difficulty in identifying new growth on bitterbrush, first-year height growth was not measured.

Table 6.--*Mean survival and statistical significance*[1] *for bitterbrush nursery stock*

Time of lifting	Storage temperature	Package	Survival
	°F		*Percent*
Fall	28	Bag	70 ab
Fall	28	Crate	44 b
Fall	33	Bag	84 a
Fall	33	Crate	68 ab
Spring	33	Bag	92 a
Spring	33	Crate	98 a

[1] In each column, all means followed by the same letter do not differ significantly at the 95 percent level.

SUMMARY OF RESULTS

There were no significant statistical differences in first-year survival or height growth between crated and bagged spring-lifted trees. This also was true for fall-lifted trees, except for crated trees stored at the subfreezing temperature (28° F). This storage greatly reduced survival and growth of most of the seedling lots tested.

With the exceptions of the crated seedlings stored at 28° F and the ponderosa pine stock planted on the Lincoln National Forest, there were no significant differences in survival between fall-lifted and spring-lifted trees. However, height growth of some stock does appear to be affected by season of lifting. The first-year height growth of ponderosa pine and Douglas-fir was greater for fall-lifted than for spring-lifted trees. Lodgepole pine and Engelmann spruce trees, however, showed almost the same growth for both lifting seasons.

Table 7 presents a ranking according to a scale of arbitrary success values for the various species, lifting seasons, storage temperatures, and packages.

When planting on the Boise and Payette National Forests, we can expect acceptable tree seedling survival when any of the lifting, storage, and packaging techniques studied are used, except fall lifting and storage in crates at 28° F. For bitterbrush, spring lifting should be practiced when possible but, if necessary, seedlings can be lifted in the fall and stored at 33° F in bags.

None of the techniques studied resulted in good survival on the Sitgreaves or Lincoln National Forests. The precise reasons for the poorer survival and growth of these seedlings are unknown. Because they were lifted and handled in the same way as all other seedlings, we assume these trees were in equally good physiological condition when they were shipped from the nursery. However, there were more opportunities for adverse conditions to occur during shipment and local storage than for seedlings shipped to the Boise and Payette National Forests. The elapsed time from lifting to planting was about the same for all forests, but the periods of local storage on the Sitgreaves and Lincoln National Forests were much longer. Of course, the sites also were different from the central Idaho sites. Because of the success of fall lifting and winter storage in Idaho, it seems advisable to make another test of the Sitgreaves and Lincoln National Forest ponderosa pine with more detailed monitoring of the conditions between shipping and planting. Survival and height growth will be measured for two more growing seasons.

Table 7.--*Comparative ranking*[1] *for each nursery seedling lot tested, based on first-year survival*

Time of lifting	Storage temperature	Package	Boise NF				Payette NF		Sitgreaves NF	Lincoln NF	
			Ponderosa pine, 1-0	Lodgepole pine	Douglas-fir	Engelmann spruce	Ponderosa pine, 2-0	Western larch	Ponderosa pine, 2-0	Ponderosa pine, 2-0	Bitterbrush
	°F										
Fall	28	Bag	G	G	A	G	G	G	NA	NA	NA
Fall	28	Crate	A	A	NA	A	NA	G	NA	([2])	NA
Fall	33	Bag	G	G	A	G	G	G	NA	NA	A
Fall	33	Crate	G	G	A	G	A	G	A	NA	NA
Spring	33	Bag	G	G	G	G	G	G	NA	A	G
Spring	33	Crate	G	G	G	G	G	G	NA	A	G

[1] Greater than 90 percent survival --- Good (G)
75-90 percent survival ---------- Acceptable (A)
Less than 75 percent survival ------ Not acceptable (NA)

[2] These seedlings were inadvertently removed from storage and mixed with nonstudy stock.

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